

## Worcester Polytechnic Institute DigitalCommons@WPI

---

Computer Science Faculty Publications

Department of Computer Science

---

5-1-2006

# Towards Enabling Collaboration in Intelligent Tutoring Systems

Kevin Kardian

*Worcester Polytechnic Institute*

Neil T. Heffernan iii

*Worcester Polytechnic Institute, [nth@wpi.edu](mailto:nth@wpi.edu)*

Follow this and additional works at: <http://digitalcommons.wpi.edu/computerscience-pubs>



Part of the [Computer Sciences Commons](#)

---

### Suggested Citation

Kardian, Kevin , Heffernan, Neil T. (2006). Towards Enabling Collaboration in Intelligent Tutoring Systems. .

Retrieved from: <http://digitalcommons.wpi.edu/computerscience-pubs/48>

This Other is brought to you for free and open access by the Department of Computer Science at DigitalCommons@WPI. It has been accepted for inclusion in Computer Science Faculty Publications by an authorized administrator of DigitalCommons@WPI.

# **Towards Enabling Collaboration in Intelligent Tutoring Systems**

**Abstract:** Intelligent Tutoring Systems have historically been shown [Koedinger, Anderson, Hadley & Mark, 1997; Morgan & Ritter, 2002] to be an effective means of educating an audience. While there is great benefit from such systems they are generally very costly to build and maintain. Currently it is estimated that 200 hours of time is required to produce one hour of Intelligent Tutoring Systems content [Murray, 2002; Anderson, 1993]. For Intelligent Tutoring Systems to be widely accepted in the classroom environment there needs to be a tool set that allows for the most novice user to maintain and grow the system with minimal cost. The goal of this work is to create such a tool set targeted towards the Assistments Project [Razzaq, Feng, Nuzzo-Jones, Heffernan, & et. al., 2005] and enable teacher collaboration within the system. A goal of the Assistments Project is to provide a means for teachers to obtain meaningful data from the system that they utilize in the classroom environment thus enabling a comprehensive learning solution.

## Introduction

The focus of this work is aimed at providing teacher tools and a means to collaborate with users in the Assistments Project [Razzaq & et. al., 2005; Nuzzo-Jones, Walonoski, Heffernan, & Livak, 2005]. The Assistments Project is an Intelligent Tutoring System whose main goal is providing tutoring for middle and high school level mathematics. Currently the system is used in several Worcester Area Schools in preparation for the MCAS [Massachusetts DOE, 2005] exams. The system provides a means for teachers to assign these tutors to their students which provide meaningful feedback and directed instructional tutoring based on the student's actions. "Collaboration" in the Assistment Project encompasses a teacher's ability to share content, classes, and data with other system users. It is believed that this collaboration will lead to better results in content produced and teacher's utilization of the system in their weekly lessons. Teacher will be able to create and assign content as well as manage their classes and students.

For the Assistments Project to be successful the ability of users to self manage the system is a necessity. There is a need for a simple but powerful interface from which users, from differing privilege levels, are able to manage the user accounts that fall under their control. Currently three levels of control in the system exist. The levels are student accounts, who maintain their account, teacher accounts that maintain their accounts as well as administer their student's accounts, their classes, and shared content, and finally there are system administrator accounts, who maintain all accounts.

## Background

An important key to having a successful Intelligent Tutoring System is for the content creation tools to be extensible. For example a mathematics expert, a person who is a mathematics teacher or in another mathematics profession, should be able to easily create mathematical content to be deployed via the Intelligent Tutoring System with little to no knowledge of what an Intelligent Tutoring System is or does.

While this work will be primarily oriented towards integration with the Assistments Project many other online tutoring systems exist; many of which provide the same rich features as the Assistments Project. The Online Learning Initiative (OLI) [CMU, 2003] from Carnegie Mellon University provides a collection of online tutors directed at many subject areas. While the OLI provides a wide range of online tutors, the tutors are lacking in extensibility resulting in a high cost for creating content. Cognitive Tutor Authoring Tools (CTAT) [Koedinger, Alevan, Heffernan, McLaren, & Hockenburry, 2004] from LearnLab also provides online tutors in addition to being extensible. However, CTAT lacks the administrative tools being investigated by this work. The National Center for Research on Evaluation, Standards and Student Testing (CRESST) [Vendlinski, Niemi, Wang, Monemoir, & Lee, 2005] not only provides an online system but also has a collection of tools to support the creation and distribution of content. However the CRESST system does not offer tutoring, instead it allows for open ended questions that are then evaluated by a human teacher. SlideTutor [Crowley, 2005] is a domain specific web-savvy tutor system directed at the medical community. This system works well for its domain but is not very extensible beyond it.

Within the Assistments Project there exists a subset of the required features for the Assistment Portal; the tool set that is to be created under this research. Originally the Assistment Portal was simply provided as a means to log into the system and begin your work. It consisted of a handful of basic functionality tailored to students and teachers. The students were able to create their account, view a list of assignments, and begin work on an assignment. Teachers were additionally given a list of the Assistments they had created plus access to the Assistment Reports [Feng, Heffernan & Koedinger, 2006] and the Assistment Builder [Turner, Macasek, Nuzzo-Jones, & Heffernan, 2005]. While this limited functionality proved to be adequate early on in the systems history eventually it was realized that a much larger tool set was needed to further the growth and development of the project.

Two additional tools that fall under the domain of the Assistment Portal are the Curriculum Creator and the Curriculum Assigner. These tools allow for the creation of a curriculum from an existing set of Assistments and the subsequent assigning of the curriculums to teachers classes. A curriculum, from an ITS perspective, is a grouping of Assistments which defines an ordering that the Assistments are presented to the users. The tools were designed to be functional and only work for a specific subset of Assistments and fall short in ease of use.

The Assistment Builder is an existing full-featured Assistment creation tool. An Assistment consists of a main question followed by a series of hints and/or follow-up questions whose goal is to assess as well as assist the students learning. While this tool does not fall directly under the domain of the Assistment Portal it is a tool that primarily teachers will have access to and will be integrated into the Assistment Portal to provide a more intuitive group of related tools.

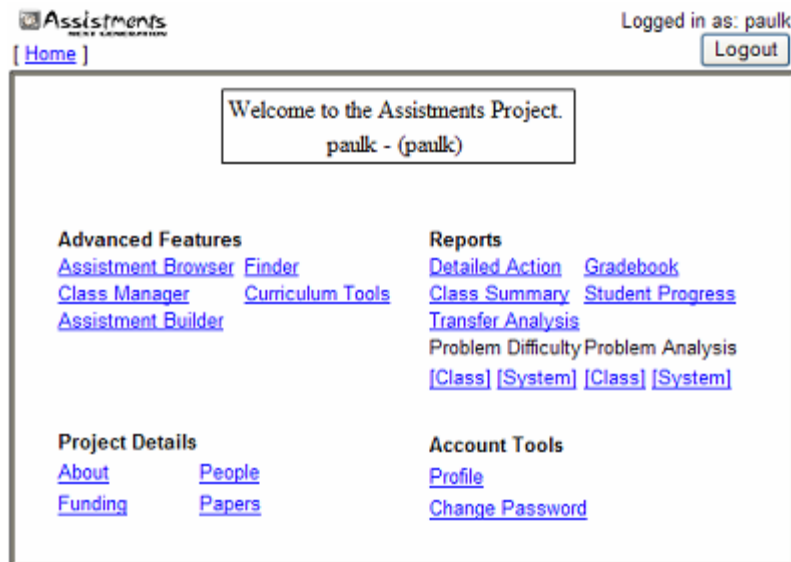
The created curriculums and Assistments are administered to students via the eXtensible Tutor Architecture which is the underlying framework of The Assistments Project. [Nuzzo-Jones & et. al., 2005]

## **Description**

Intelligent Tutoring Systems (ITS) have been proven to successfully aid student learning [Koedinger & et. al., 1997]. The current drawback of an ITS is that the creation and deployment of content requires extensive experience within the ITS discipline. Tools are needed to remove this steep learning curve allowing for an ITS to become common place in traditional school settings. Once a teacher can quickly and effectively distribute content to their students they can then utilize the feedback in the classroom setting to focus on under performing areas. Allowing teachers to take information from the ITS into the classroom will be the key for the future adoption of Intelligent Tutoring Systems and the creation a comprehensive learning solution. Such a solution hinges greatly on the successful development of tools that are usable by individuals from a limited ITS background.

The main focus of this work is in the realm of teacher tools; however some improvements to the student's portal will also be briefly discussed. Recent efforts in the Assistment Project have been made to further reengineer the system into separate well defined components [Nuzzo-Jones, Macasek, Walonoski, Rasmussen & Heffernan, 2006] to improve its modularity and extensibility. The Assistment Portal was redesigned to echo this new focus and as such each tool is designed independent of the others to allow for its modularity and extendibility. Tools can easily be swapped out of the system with no impact on other tools or functionality in the system. The only drawback in the design of the tools is that they are tied to our system as they utilize our very specific data model. As a result they are not pluggable into any arbitrary system as is; some modification is required to make them fit another systems data model.

With the tools that have been added there is now significantly more functionality related to the development, deployment, and management of content as well as the added ability for teachers to manage their classes. The new underlining theme found in much of the Assistment Portal (see Figure 1) is collaboration. This collaboration is possible between teacher users as well as other content creators throughout the system.



**Figure 1. Assistment Portal; Teacher User**

## Account Creation

In order to use the Assistment System an account is required. This can be accomplished easily from our account creation page. Teacher Accounts can be created via our new account creation page. When an account is created it will be associated with a school, either already in the system or a newly created school, which will allow teachers the opportunity to collaborate among other teachers and content creators in that school and/or system wide. During teacher account creation initial classes can also be setup. These classes will then have associated assignments which are completed by students who join that particular class.

## Assistment Browser

The Assistment Browser is a tool used for the manipulation of users Assistments. From the Assistment Browser it is possible to view your Assistments, “Released Assistments”, and any shared Assistments from other teachers. “Released Assistments” are Assistments that have been developed by the Assistment Project Team and are viewable by all users in the system. From the Assistment Browser a teacher is able to preview, edit, and markup content as long as that teacher has permission for that particular item. There are two levels of permissions: *read* and *write*. A user has inherent *write* privileges to his/her own Assistments, “Release Assistments” are available as *read* only. When establishing a share the owner can specify the privilege to grant to a user or group of users.

Assistment Shares (see Figure 2) can be created in two ways. First an author, the individual who created the content, can share all their Assistments with a user or a group of users and second an author can select specific Assistments to share from their list of Assistments. It is important to note that if all Assistments are shared this will also add newly created items to this share. The advantage here is that the authors do not have to specify a new share after they have created a new item. When creating the share the author will have the option to set the permission level for the Assistments in the share. If the author selects all Assistments it will set the permission for all the Assistments otherwise you will be given the opportunity to specify permission per Assistment in the share. Before the share is complete it must be associated with users that will be able to view it. A share can be associated with all the teachers in your school, all the teachers in the system, or selected teachers from your school and/or the system.

## Share All My Assistments

**Step 1** - Please specify the permissions to grant for the selected Assistments.

All My Assistments

**Step 2** - Select who to share these assistments with.

- | Groups you are in:                   | Teachers in your school:                    |
|--------------------------------------|---|
| <input type="checkbox"/> ForestGrove | <input type="checkbox"/> Bogomil            |
| <input type="checkbox"/> teachers    | <input type="checkbox"/> Jason Walonoski    |
|                                      | <input type="checkbox"/> Michael A. Macasek |
|                                      | <input type="checkbox"/> Goss Nuzzo-Jones   |
|                                      | <input type="checkbox"/> olga               |
|                                      | <input type="checkbox"/> venera             |
|                                      | <input type="checkbox"/> emm                |

### Other System Users

Username:

[Add more input field\(s\)](#) [Remove field\(s\)](#)

**Step 3** - Once you have completed Step 1 and Step 2 click below.

**Figure 2. Creating an Assistment Share**

Creating an Assistment Share is a way to enable collaboration among fellow teachers creating content as well as allowing other teachers to use shared content in their curriculums. Through this collaboration ideas can be shared, content can be perfected, and new techniques can be discovered. As more and more teachers join the system they will benefit from the ever increasing amount of existing content and be able to augment it with their own.

## Curriculum Manager

The Curriculum Manager is a tool designed to deploy content to students. With this tool a teacher can create new curriculums, edit existing curriculums, and assign curriculums to their classes. Curriculums can also be shared in much the same way as Assistments are shared. There are several types of curriculums that can be created, but for the most part a curriculum can be thought of as a collection of Assistments. This collection can come from the users own Assistments or any viewable Assistments whether that is via a share or the “Released Assistments”. Currently the Curriculum Manager is capable of creating two types of curriculums: Linear and Random. A Linear Curriculum is a curriculum in which the order that the Assistments are presented to the student is the same order that was used when the curriculum was created. Alternatively a Random Curriculum presents the Assistments to the student in a random order independent of how they were inserted into the curriculum.

Curriculum Sharing (see Figure 3) allows a teacher to share their existing and newly created curriculums with other teachers in their school or system wide. When a curriculum is shared it can then be assigned by any teacher in the share thus allowing their classes to use the curriculum. For example in a given school, this sharing will allow teachers to collaborate on their schedules and ensure that their classes remain in some manor of synchronization as their student’s progress through their assignments.

[Curriculum Browser](#) > [Curriculum Listing](#) > Share Assistments

## Share Curriculums

**Step 1** - Please specify the permissions to grant for the selected curriculums.

154 MA/curriculum_Unit1_Integers_v01.xml	<a href="#">Read</a>
120 MA/curriculum_Unit2_Equations_v01_bgjarusso.xml	<a href="#">Read</a>
128 MA/curriculum_slope_quiz_v01_bevg.xml	<a href="#">Read</a>

**Step 2** - Select who to share these curriculums with.

<b>Groups you are in:</b>	<b>Teachers in your school:</b>
<input type="checkbox"/> ForestGrove	<input type="checkbox"/> Bogomil
<input type="checkbox"/> teachers	<input type="checkbox"/> Jason Walonoski
	<input type="checkbox"/> Michael A. Macasek
	<input type="checkbox"/> Goss Nuzzo-Jones
	<input type="checkbox"/> olga
	<input type="checkbox"/> venera
	<input type="checkbox"/> emm

**Other System Users**  
 Username:   
[Add more input field\(s\)](#) [Remove field\(s\)](#)

**Step 3** - Once you have completed Step 1 and Step 2 click below.

[Share Curriculum\(s\)](#)

Figure 3. Creating a Curriculum Share

## Class Manager

The Class Manager application allows a teacher to manager their classes, students, and control who else can view the class information. Adding, modifying, and removing classes are useful for year to year changes in schedules. Student management allows a teacher to add a new student to the system and to a particular class. Additionally if a student has accidentally signed up for a class or has transferred out of a class the teacher can remove them from the class. Students and classes can have additional metadata associated with them to further describe the nature of a class or the abilities of a student. Teachers also have the ability to reset a student's password in the event a student forgets their password.

Logged in as: Michael A. Macasek [Logout](#)

[Home](#)

### Class Summary Report

Note: This report is generated periodically. Summary information for classes is given based on history data. Data for class running today won't be included.

Class:	Class 2 - Paul King
Transfer model:	WPI-Apr-2005
Options:	show top 5 well-done knowledge components, top 5 hard knowledge components <input type="checkbox"/> show results for classes separately; Only show knowledge components that have been met at least 10 times; Only show knowledge components tagged to at least 3 items; <input type="checkbox"/> Time period from 2005 - 1 - 1 to 2005 - 1 - 1
<input type="button" value="Submit"/>	

Figure 4. View Class Reports for a class that is shared

Classes are, much like Assistments and Curriculums, sharable to other teachers in the system. This feature will allow teachers to share classes with teacher aids and/or supervisors. With class sharing a school departmental structure could be mimicked to allow appropriate supervisors access to classes making them able to assist in the management of the class and reviewing of the student's progress via Assistment Reports (see Figure 4).

## **Assistment Finder**

The Assistment Finder is a tool that allows users of the system to locate just about any type of data for which they have access privileges. This includes classes, Assistments, curriculums, students, teachers, and more. Users can search over the entire system or restrict their search to particular types of data. This tool is very useful in that if a teacher is part of many Assistment Shares and is interested in viewing all the questions they are able to view related to a certain concept they can easily use the Assistment Finder to locate relevant items.

## **Account/Preference Tools**

Teachers are able to customize their Assistment Project experience by manipulating the systems preferences to more suit their taste. Each application can allow a user to customize how it looks and in some cases responds to the user's actions.

## **Student Users**

Student Users have a specialized Assistment Portal interface that is tailored to allow them to quickly logon to the system and get to work. Students create accounts by providing a screen name, an optional password, and specify which school they attend. Once a student has an account they can perform one of two tasks. First they can join any class that is available in their school. After a student joins a class they can only be removed from that class by the teacher of that class. Once a student is a member of at least one class the student may then select that class and work through any of his/her assignments that have been provided by the teacher for that class.

## **Methods**

Before creating this tool set, input was gathered from various sources to ensure the resulting applications were complete and met the expectations of the users. The primary source of this input came from existing users who were questioned to identify what features they were interested in adding to the Assistment System. While the responses varied to some degree most agreed that they desired the ability to collaborate via the Assistment Project with teachers in their school in a similar fashion that they do in their traditional classroom settings. The collaborations requested included the ability to share resources and results of students using the system. Based on this initial feedback tools were then constructed to meet this collaboration goal.

Internal to the Assistment Project, from the software engineering perspective, there was a push to develop pluggable components that operated independently of each other so they could be swapped into and out of the system with ease. Design of each application was centered on this goal. During the development of these tools several iterations of each tool was produced each of which was reviewed by independent Assistment Project team members and teachers to assess the tools ability to live up to its intended purpose. Through this process each tool was refined to further meet the needs and requirements of the users producing a stronger product.

In addition surveying all users' log data that is captured by usage of the Assistment Portal allows insight to how the typical teacher utilizes these tools. In reviewing this log data some weaknesses in design were made evident by what a teacher wanted to do given a certain state. This information helped in refining the tools as well.

## **Conclusion**

The Assistment Portal now consists of a mature tool set that enables teachers to more effectively utilize the Assistment System. Collaboration between system users allows users to maintain and develop content and share their work with others. The Assistment Portal will continue to evolve to meet the ever



increasing needs of its users. With this tool set teachers are now in a position to incorporate the Assistment Project into their classroom environment enabling the creation of a comprehensive learning solution.

## Reference

- Anderson, J.R., (1993). *Rules of the Mind*. Hillsdale, NJ: Erlbaum.
- Crowley RS, Legowski E, Medvedeva O, Tseytlin E, Roh E, Jukic DM. (2005). An ITS for medical classification problem-solving: Effects of tutoring and representations. In C.K. Looi, G. McCalla, B. Bredeweg, & J. Breuker (Eds.) *Proceedings of the 12th Artificial Intelligence In Education*, 555-562. Amsterdam: ISO Press.
- Feng, M., Heffernan, N.T, Koedinger, K.R. *Addressing the Testing Challenge with a Web-Based E-Assessment System that Tutors as it Assesses*. Submitted to WWW2006, Edinburgh, Scotland (2006).
- Koedinger, K. R., Aleven, V., Heffernan, T., McLaren, B. & Hockenberry, M. (2004) Opening the Door to Non-Programmers: Authoring Intelligent Tutor Behavior by Demonstration. *Proceedings of 7<sup>th</sup> Annual Intelligent Tutoring Systems Conference*, Maceio, Brazil. pg.162-173.
- Koedinger, K. R., Anderson, J. R., Hadley, W. H., & Mark, M. A. (1997). Intelligent tutoring goes to school in the big city. *International Journal of Artificial Intelligence in Education*, 8, 30-43.
- Morgan, P., & Ritter, S. (2002). An experimental study of the effects of Cognitive Tutor® Algebra I on student knowledge and attitude. (Available from Carnegie Learning, Inc., 1200 Penn Avenue, Suite 150, Pittsburgh, PA 15222).
- Murray, T. (1999). Authoring Intelligent Tutoring Systems: An Analysis of the State of the Art. *International Journal of Artificial Intelligence in Education*, 8, 30-43.
- Nuzzo-Jones G., Macasek MA., Walonoski, JA., Rasmussen K., Heffernan NT. *Common Tutor Object Platform – an e-Learning Software Development Strategy*. Submitted to WWW2006, Edinburgh, Scotland (2006).
- Nuzzo-Jones, G., Walonoski, J.A., Heffernan, N.T., Livak, T. (2005). The eXtensible Tutor Architecture: A New Foundation for ITS. In C.K. Looi, G. McCalla, B. Bredeweg, & J. Breuker (Eds.) *Proceedings of the 12th Artificial Intelligence In Education*, 555-562. Amsterdam: ISO Press.
- Published by Carnegie Mellon University (2003), Open Learning Initiative (OLI), <http://www.cmu.edu/oli/>.
- Published by Massachusetts Department of Education (2005), Massachusetts Comprehensive Assessment System, <http://www.doe.mass.edu/mcas/>.
- Razzaq, L, Feng, M., Nuzzo-Jones, G., Heffernan, N.T. et. al (2005). The Assistment Project: Blending Assessment and Assisting. In C.K. Looi, G. McCalla, B. Bredeweg, & J. Breuker (Eds.) *Proceedings of the 12th Artificial Intelligence In Education*, 555-562. Amsterdam: ISO Press.
- Turner, T.E., Macasek, M.A., Nuzzo-Jones, G., Heffernan, N.T., Koedinger, K. (2005). The Assistment Builder: A Rapid Development Tool for ITS. In C.K. Looi, G. McCalla, B. Bredeweg, & J. Breuker (Eds.) *Proceedings of the 12th Artificial Intelligence In Education*, 555-562. Amsterdam: ISO Press.
- Vendlinski, T., Niemi, D., Wang, J., Monempour, S., Lee, J. (2005). Improving Formative Assessment Practice with Educational Information Technology. *American Educational Research Association 2005 Annual Meeting*.

## Acknowledgements

I would like to thank the Worcester, MA area schools for their continuing support of the Assistment Project. Additionally would like to acknowledge the US Department of Education, National Science Foundation, and Office of Naval Research, for providing the funding to accomplish this research.